Enumeration of the 1997 Harrison River Chinook Salmon Escapement

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ENUMERATION OF THE 1997 HARRISON RIVER CHINOOK SALMON ESCAPEMENT

by

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In 1985, the Pacific Salmon Treaty committed the Canadian Department of Fisheries and Oceans to halt the decline in abundance of chinook salmon (*Oncorhynchus tshawytscha*) stocks. The Harrison River was designated a chinook indicator stock, and escapement has been monitored annually since 1984. In 1997, 1,576 marks were applied and 99 were recovered in a recovery sample of 4,780 chinook. In females, a spatial bias was detected in the application sample. There was a bias to female carcasses in the recovery sample. Small sample size statistical bias was present in precocious males. Handling stress resulted in an altered recovery rate in recaptured fish and in those that required assistance after marking. The accuracy of field identification of precocious males was low. The escapement estimates derived by the Petersen formula were 48,503 males, of which 1,819 were precocious males, and 25,593 females. The total adult escapement estimate (74,096) was the fourth lowest since monitoring began in 1984.

Key Words: Chinook salmon, Harrison River, indicator stock, escapement, Pacific Salmon Treaty.

RÉSUMÉ

M. K. Farwell, R. E. Bailey, and B. P. Whitehead. 2000. Enumeration of the 1997 Harrison River chinook salmon escapement. Can. Manuscr. Rep. Fish. Aquat. Sci. 2505: 38 p.

En 1985, le Traité sur le saumon du Pacifique prévoyait que le ministère canadien des Pêches et des Océans devait mettre fin au déclin des stocks de saumons quinnats (*Oncorhynchus tshawytscha)*. Le stock des saumons quinnats de la rivière Harrison fut choisi comme indicateur de l'espèce et son échappée est observée tous les ans depuis 1984. En 1997, après le marquage de 1 576 poissons, on a pu retrouver 99 spécimens marqués dans un échantillon de 4 780 saumons quinnats prélevés à cet effet. Un biais spatial a été détecté pour l'échantillon d'application dans le cas des femelles. Les chercheurs ont observé un biais se traduisant par un plus grand nombre de femelles marquées parmi les carcasses récupérées. On a également observé un biais statistique dû à la faible taille de l'échantillon pour les mâles précoces. Le stress infligé aux poissons lors de leur manipulation s'est traduit par un taux de récupération faussé pour les poissons recapturés et pour ceux qui ont eu besoin d'aide après leur marquage. La précision de l'identification sur le terrain des mâles précoces était faible. L'échappée estimée, calculée à l'aide de la formule de Petersen, s'est élevée à 48 503 mâles, dont 1 819 étaient des mâles précoces et 25 593 des femelles. Seules trois autres échappées mesurées depuis le début des mesures en 1984 étaient inférieures à l'échappée totale estimée (74 096 saumons) pour 1997.

Mots clés : Saumon quinnat, rivière Harrison, stock indicateur, échappée, Traité sur le saumon du Pacifique.

INTRODUCTION

The 1985 Pacific Salmon Treaty committed management agencies in Canada and the United States of America to halt the decline in chinook salmon (*Oncorhynchus tshawytscha*) spawning escapements and to attain, by 1998, escapement goals established by each nation (Anon. 1985). To evaluate rebuilding progress, the Department of Fisheries and Oceans has monitored a group of key stocks selected to represent all British Columbia chinook stocks. The status and response to management actions of these stocks are evaluated by measuring, with known precision, either annual trends in escapement (escapement indicator stocks) or in escapement and total harvest (exploitation rate indicator stocks).

The Harrison River was designated an escapement indicator stock in 1984 because it comprised almost one-third of the Fraser River system chinook escapement in the 1970s (Farwell et al. 1987). As a predominantly white-fleshed, fall spawning stock with juveniles which migrate to sea immediately following emergence (Fraser et al. 1982), it is unique in the Fraser River system. Individual monitoring, therefore, was warranted. Previous reports documented the 1984-1996 Harrison River chinook enumeration studies (Staley 1990; Farwell et al. 1990, 1991, 1992, 1996, 1998, 1999; Schubert et al. 1993, 1994). The current report documents the 1997 field methods, analytic techniques, and study results. Included are estimates of age, length, sex, adipose fin clip (AFC) incidence, coded wire tag (CWT) recoveries, and escapement by sex and age. The report concludes with a discussion of data limitations and escapement trends.

STUDY AREA

The Harrison River is part of a complex system which drains a mountainous coastal watershed in southern British Columbia (Fig. 1). The river originates at Harrison Lake and flows south-west for 16.5 km, entering the Fraser River 116 km upstream from the Strait of Georgia. Between 1951 and 1994, the river had an annual mean daily discharge of 440 $m^3 \times s^{-1}$, with an annual mean daily maximum of 1269 $m^3 \times$ s-1 and minimum of 121 $m^3 \times$ s-1 measured at the outlet of Harrison Lake (unpublished data, pers. comm. Lynne Campo, Environment Canada). Flow extremes are moderated by Lillooet and Harrison lakes. To facilitate bias analyses, the study area was divided into eight reaches based on changes in stream channel physical characteristics (Fig. 2):

Reach 1 (Harrison Lake to km 9.5), from the lake to Morris Creek, has a wide, low gradient channel with a depth of 10 m and a sand substrate;

Reach 2 (km 9.5 to 7.7) extends to Billy Harris Slough on the north-west shore and to the top of Reach 5 on the south-east shore. The channel is similar to Reach 1 except the depth is 3.0 m and the substrate is gravel;

Reach 3 (km 7.7 to 7.1) extends to a shear boom on the north-west shore. It has a higher gradient and a cobble/gravel substrate;

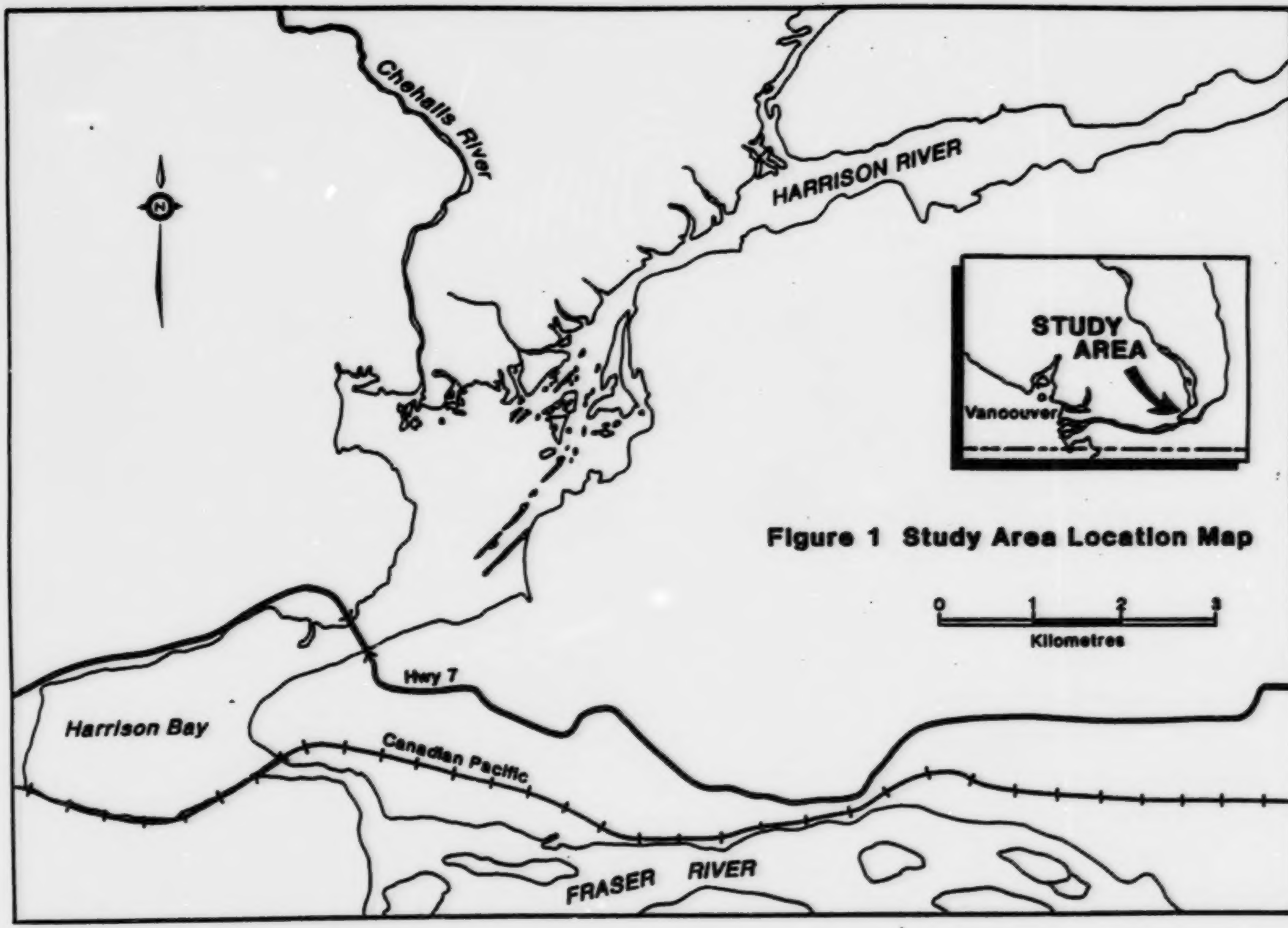

Fig. 1. Study area location map.

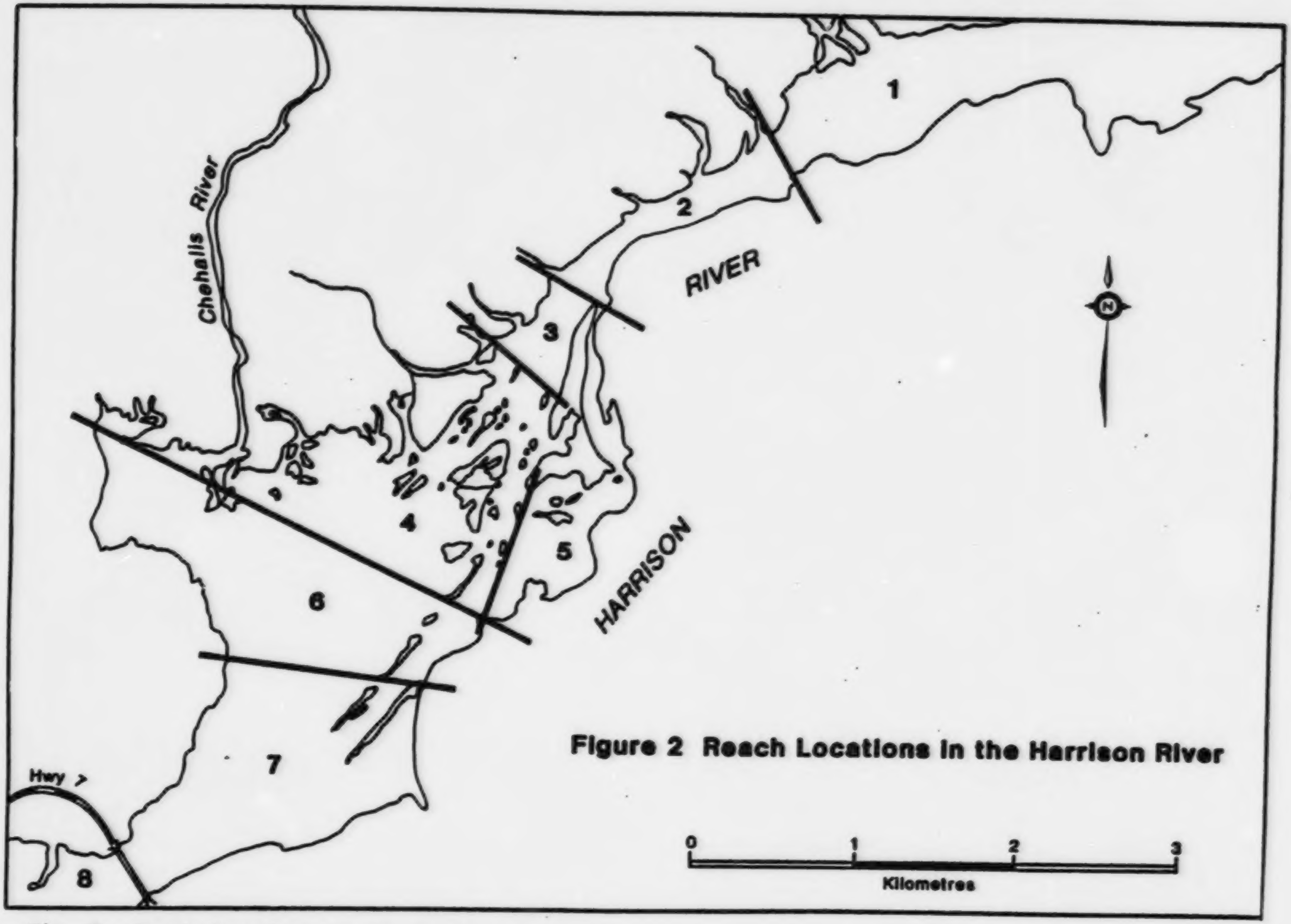

Fig. 2. Reach locations in the Harrison River.

Reach 4 (km 7.1 to 6.3) is similar to Reach 3 except there are several side channels on the north-west shore separated from the main channel by gravel bars. The channel substrate is gravel;

Reach 5 (km 7.7 to 6.3) is a large side channel with a low gradient, a depth of 1.5 m and a sand substrate. An island at the mid-point divides the reach into two sections;

Reach 6 (km 6.3 to 4.5) extends to a rock bluff on the south-east shore, 2 km above the Highway 7 bridge, and includes the main channel and the upper Chehalis River flood plain. The channel depth is 3 m and the substrate is bedrock/gravel;

Reach 7 (km 4.5 to 3.0) extends to the Highway 7 bridge, and includes the main channel and the lower Chehalis River flood plain. The gradient is lower than Reach 6 and the substrate is mud;

Reach 8 (km 3.0 to 0) extends to the Fraser River and includes Harrison Bay. The river is deep (up to 4 m) and slow, flowing over a sand and gravel substrate. Harrison Bay is shallow with a mud substrate. There are several mid-river entrainment structures designed to divert the flow away from Harrison Bay. The bay dewaters at low Harrison River discharges, and chinook tend to avoid the area.

FIELD METHODS

TAG APPLICATION

Chinook salmon were captured in reaches 2 through 4 from October 14 to November 19, 1997 using a 67 m x 6 m x 9 cm-mesh seine net. The net was set by power boat in a downstream crescent and withdrawn from the river to enclose a small area of water along the river bank. Captured chinook were held in the net until removed for tagging and release. Spaghetti tags were applied in a submerged wooden tray constructed with a flexible plastic bottom and a meter stick recessed in one side. After tagging, the fish were released over a submerged section of the net; at no time were they removed from the water. During tag application, any previously tagged fish that were recaptured were released without removal from the water. Date, reach, and tag number were recorded for recaptured fish.

The spaghetti tags consisted of a 50 cm long, 2 mm diameter hollow plastic tube numbered with a unique code. The tag was inserted with a 13 cm long stainless steel needle through the musculature and pterygiophore bones 2 cm below the anterior portion of the dorsal fin. It was tied tightly over the dorsal surface with a square knot. Each tagged fish received a secondary mark to allow the assessment of tag loss. One 7 mm diameter hole was punched through the left operculum of males and jacks using a single hole punch. Female left opercula were punctured twice. Care was taken to avoid gill damage. Field sex identification was based on developing secondary sexual characteristics. Field distinction between adult and precocious males (jacks) was based on nose-fork (NF) length with jacks having a NF of less than 65 cm. Date and location (reach) of capture, tag number, sex, NF length (±0.5 cm) and adipose fin status were recorded for each chinook released with a tag. Release condition was recorded as 1 (swam away vigorously), 2 (swam away sluggishly) or 3 (required ventilation).

SPAWNING GROUND SURVEYS

The spawning grounds were surveyed from October 28 to December 3, 1997. Complete surveys were conducted weekly by two-person crews, with two to four crews required depending on carcass abundance. The shore was surveyed on foot while deep water areas, including the mid-river entrainment structures, were surveyed by boat. Carcasses were recorded by date, reach, recovery type (shore or deep water), sex (confirmed by abdomen incision), and mark type (spaghetti tag, secondary mark or AFC). Carcasses identified as male were classed as jacks if the POH length was less than 52 cm or as adult if the POH length was greater than 52 cm. Each marked carcass, AFC carcass and every tenth unmarked carcass was sampled, as were all carcasses that were borderline for classification as either adult male or jack. All were cut in two with a machete and returned to the river.

Sample data, recorded by date and reach, included postorbital-hypural plate (POH) length (±0.5 cm), sex, female spawning success (0%, 50%, or 100% spawned), adipose fin condition, flesh colour, and scales. For AFC chinook, the head was removed posterior to the eye orbit for later CWT identification. Adipose fin condition was recorded as unclipped or as complete (flush with dorsal surface), partial (nub present) or questionable (appeared clipped but fungus or decomposition obscured the area). The condition of AFC carcasses was recorded as fresh (gills red or mottled), moderately fresh (gills white, body firm), moderately rotten (body intact but soft), or rotten (skin and bones), and the absence of one or both eyes was noted.

ANALYTIC PROCEDURES

TESTS FOR SAMPLING SELECTIVITY

Period

Temporal bias, within each sex group, was assessed using a chi-square test (Sokal and Rohlf 1981). Application bias was examined by comparing among periods the mark incidence in the recovery sample, where mark incidence was the proportion of the chinook marked with either a spaghetti tag or a secondary mark. Recovery bias was examined by stratifying the application sample by period and comparing proportions recovered.

Location

Spatial bias, within each sex group, was assessed using a chi-square test. Application bias was examined by comparing among river sections the mark incidence in the recovery sample. Recovery bias was examined by stratifying the application sample by section and comparing the proportions recovered.

Fish Size

Size related bias, within each sex group, was assessed using the Kolmogorov-Smirnov two-sample test (Sokal and Rohlf 1981). Application bias was examined by comparing the POH length frequency distributions of marked and unmarked spawning ground recoveries.

Recovery bias was examined by partitioning the application sample into recovered and non-recovered components and comparing the NF length frequency distributions of each.

Fish Sex

Sex related bias was assessed using a chi-square test. Application bias was examined by comparing the sex ratio of the marked and unmarked spawning ground recoveries. Recovery bias was examined by partitioning the application sample into recovered and non-recovered components and comparing the sex composition in each. Precocious males, as determined by length were treated as a separate group.

Other Tests

Bias resulting from tagging stress was also assessed using the chi-square test. The application sample was partitioned by the three categories of release condition and recovery rates were examined among groups. Bias associated with the stress of recapture of previously tagged fish was also assessed. The rate of recovery in recaptured and not recaptured groups were compared using a chi-square test. As well, differential spawning success, as indicated by egg retention in female carcasses, was examined in marked and unmarked spawning ground recoveries.

Statistical bias in the mark-recovery estimation method was deemed present when there were fewer than four recoveries in a class (Ricker 1975). Statistical bias in the chi-square tests was deemed present when the expected frequency in a class was less than five (Sokal and Rohlf 1981). Where appropriate, classes were pooled to decrease statistical biases. In those instances when pooling was not appropriate, the offending class was omitted from the analysis.

ESTIMATION OF SPAWNER POPULATION

Total Escapement

The 1997 escapement of Harrison River chinook was calculated from the mark-recovery data using the Petersen formula (Chapman modification) (Ricker 1975). Total escapement was the sum of escapement by sex as calculated by the following formulae:

1) Estimated Harrison River chinook escapement (N_t):

$$Nt = N_{ma} + N_f + N_{mjk} \qquad \textit{(Equation 1)}$$

where the adult male escapement (N_{ma}) was calculated as:

$$N_{ma} = \frac{(M_{ma} + 1)(n_{ma} + 1)}{(m_{ma} + 1)} \qquad \textit{(Equation 2)}$$

where:

M_{ma} = number of adult males released with primary and secondary marks corrected for sex identification errors;

m_{ma} = number of primary and/or secondary marked adult male carcasses recovered; and

n_{ma} = number of adult male carcasses examined for marks.

Standard error (square root of the variance) of the adult male escapement estimate was calculated as:

$$SE_{ma} = \sqrt{\frac{(N_{ma}^{2})(n_{ma} - m_{ma})}{(n_{ma} + 1)(m_{ma} + 2)}} \qquad \textit{(Equation 3)}$$

and the 95% upper and lower confidence limits on the adult male estimate were calculated as:

$$N_{ma} \pm 1.96\ SE_{ma}$$

The female (N_f) escapement and standard error (SE_f) were calculated in an analogous manner. The jack (N_{mjk}) escapement and its standard error (SE_{mjk}) were similarly calculated; however, as jacks were defined based on a length criterion, jack data were not corrected for sex identification errors. Confidence limits on the total escapement were calculated from the square root of the summed adult male, female, and jack variances.

Sex Identification Correction

Identification errors occurred because sexually dimorphic traits may not be fully developed at the time of marking and internal examinations were not possible until the carcass survey. Tag application data were corrected for sex identification error using the method described by Staley (1990).

The corrected number of adult males released with primary and secondary marks (M_{ma}) was estimated as:

$$M_{ma} = \frac{M^{*}_{ma} - ((M_{ta})(m_{ma,f}))/m_f}{1 - (m_{ma,f}/m_f) - (m_{f,ma}/m_{ma})} \qquad \textit{(Equation 4)}$$

where:

M^{*}_{ma} = number released with primary and secondary marks identified as adult male at mark application;

M_{ta} = total number of adult males and females released with primary and secondary marks;

m_{ma} = adult males recovered with primary or secondary marks;

m_f = females recovered with primary or secondary marks;

$m_{ma,f}$ = females identified as adult male at mark application; and

$m_{f,ma}$ = adult males identified as female at mark application

The corrected number of females (M_f) was, by subtraction:

$$M_f = M_{ta} - M_{ma} \qquad \textit{(Equation 5)}$$

The estimated number of jacks (M_{mjk}) was not corrected because they were distinguished by length criteria in both samples.

The analysis of bias requires the application sample to be stratified in a variety of ways. To determine the corrected number of adult males within a stratum (M_m^s) the uncorrected total number of adult males in the stratum ($M^*{}_m^s$) is substituted for ($M^*{}_m$) and the uncorrected total adult marks applied in the stratum (M_t^s) is substituted for (M_t) in *Equation 4*. The corrected number of female chinook within a stratum is calculated by substitution of stratum specific data into *Equation 5*.

Escapement by Age

The estimated escapement of an age group was the product of the sex specific escapement and the proportion of an age group in the total of the aged fish, stratified by sex. Confidence limits were not estimated.

Adipose Fin Clipped Escapement

The estimated AFC escapement was the product of the AFC incidence in the recovery sample, the largest of the two available samples, and the mark-recovery escapement estimate stratified by sex. If no significant difference between AFC incidence in the sex groups was detected then a pooled estimate of AFC incidence was utilised. Confidence limits and escapement by CWT code were not estimated.

RESULTS

SPAGHETTI TAG APPLICATION

Spaghetti tags and secondary marks were applied to 1,799 chinook in the Harrison River from October 14 to November 19, 1997 (Appendix 1). Sex identification at mark application indicated there were 1,010 adult males, 680 females, and 109 jacks. Based on the sex identification at mark recovery, three of the fish were misidentified by sex at the time of tagging (Appendix 2). In addition, one jack in the recovery sample was identified as an adult male at mark application After correction for the sex identification errors in adult chinook, the marked releases were 1,048 adult males, 642 females, and 109 jacks. The mark recovery rate was significantly higher than expected in the females that required ventilation assistance at release ($p < 0.05$; chi-square). No significant difference was observed in males; however, small sample size may have affected the result. Therefore, all three fish that required ventilation assistance were removed from the application sample (Table 1). Mark recovery rates were significantly different in those fish which were recaptured during subsequent tag application periods ($p < 0.05$; chi-square). Further testing indicated that the recovery rate for fish that were recaptured a single time was significantly different than that for fish that were never recaptured (Table 2). Therefore, all 220 recaptured fish were removed from the application sample. Of the remaining 1,576 chinook, 938 were adult males, 545 females and 93 were jacks (Table 3). Sixteen of the marked fish (0.9%) had an AFC (Appendix 1).

Table 1. Spaghetti tag application and recovery, by release condition and sex, of Harrison River chinook salmon, 1997.

Release condition	Tags applied [a]			Tags recovered			Percent recovered		
	Male	Female	Jack	Male	Female	Jack	Male	Female	Jack
Swam rapidly	846	491	98	34	40	2	4.0%	8.2%	2.0%
Swam sluggishly	192	147	10	7	8	0	3.6%	5.5%	0.0%
Required assistance	1	2	0	0	1	0	0.0%	50.2%	-
Unknown	8	3	1	0	0	0	0.0%	0.0%	0.0%
Total	1,048	642	109	41	49	2	3.9%	7.6%	1.8%

a. Corrected for sex identification errors; rounding error may be present.

Table 2. Spaghetti tag application and recovery, by number of recaptures during tag application, by sex, of Harrison River chinook salmon, 1997.[a]

Number of times recaptured	Tags applied [b]			Tags recovered			Percent recovered		
	Male	Female	Jack	Male	Female	Jack	Male	Female	Jack
0	938	545	93	36	43	1	3.8%	7.9%	1.1%
1	92	73	11	4	5	1	4.3%	6.8%	9.1%
2	11	15	3	0	0	0	0.0%	0.0%	0.0%
3	2	2	1	0	0	0	0.0%	0.0%	0.0%
4	2	1	1	0	0	0	0.0%	0.0%	0.0%
5	2	1	0	1	0	0	48.1%	0.0%	-
6	0	2	0	0	0	0	-	0.0%	-
7	0	0	0	0	0	0	-	-	-
8	0	0	0	0	0	0	-	-	-
9	0	1	0	0	0	0	-	0.0%	-
Total	1,047	640	109	41	48	2	3.9%	7.5%	1.8%

a. Excludes 3 fish which required ventilation assistance at release.

b. Corrected for sex identification errors; rounding errors may be present.

Table 3. Spaghetti tag application, carcass examination, and mark recovery, by sex, of Harrison River chinook salmon, 1997.[a]

			Marks recovered				
Sex	Spaghetti tags applied [b]	Carcasses examined	Spaghetti tag and secondary mark	Secondary mark only	Spaghetti tag only	Total	Percent recovered
Male	938	2,391	35	13	1	49	5.2%
Female	545	2,249	36	4	7	47	8.6%
Jack	93	52	1	1	0	2	2.2%
Unknown	-	88	0	0	1	1	-
Total	1,576	4,780	72	18	9	99	6.3%

a. Excludes 220 recaptured fish and 3 that required ventilation assistance at release.

b. Corrected for sex identification errors; rounding error may be present.

Most (89.3%) of the marked chinook were released in Reach 2; an additional 10.4% were released in Reach 3 and the remaining 0.2% were released in Reach 4. Of the recaptured chinook, 92.0% were recaptured in Reach 2.

Mean and range of NF lengths of adult males, females, and jacks were 83.3 cm (64 to 115 cm), 83.4 cm (60 to 109 cm) , and 55.9 (38 to 65 cm), respectively. There was no distinct separation interval between the NF length frequency distributions of precocious and adult males (Figure 3) (Table 9). To minimize handling time and associated stress, the mark application group was not sampled for age.

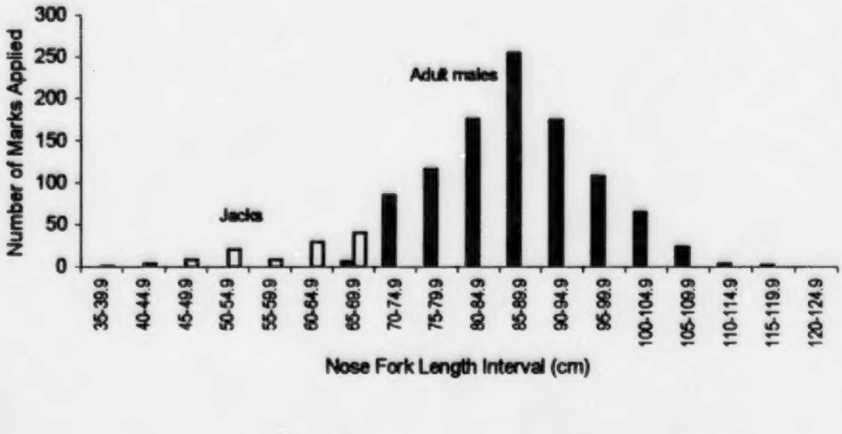

Figure 3. Nose fork length frequency distribution for male chinook marked in the Harrison River, 1997.

SPAWNING GROUND RECOVERY

In 1997, a total of 4,792 chinook salmon were recovered on the spawning grounds from October 28 to December 3 (Appendix 3). Twelve of the recovered marked carcasses were deleted from the recovery sample: one which had required ventilation assistance at release (Table 1) and eleven which had been recaptured during mark application (Table 2). Of the remaining 4,780 carcasses, there were 2,391 (50.0%) adult male, 2,249 (47.1%) female, and 52 (1.1%) jack carcasses recovered (Table 3). In addition, sex could not be determined for 88 (1.8%) of the carcasses.

Seventy two (1.5%) of the recovery sample carcasses bore a spaghetti tag and a secondary mark while 18 (0.3%) carcasses showed spaghetti tag loss and secondary marks were not identified on 9 (0.2%) carcasses. Thirty one (0.6%) of the carcasses bore an AFC (Appendix 3). Tag loss, as indicated by carcasses with only a secondary mark, was significantly higher in males (adult and jacks combined) (27.5%) than in females (2.1%) ($p < 0.05$, chi-square). Tag loss between males (26.5%) and jacks (50.0%) was significantly different; however, the results may be biased by the small jack sample size. Of the 9 tags which were recovered without a secondary mark, 2 were recovered from carcasses with incomplete or damaged opercula, 5 were from rotten carcasses, and 3 were from fresh carcasses. Most (63.6%) of the chinook carcasses were recovered in the middle section (reaches 3 to 5) while 35.4% were recovered in the lower section (reaches 6 to 8) and 0.9% were recovered in the upper section (reaches 1 and 2) (Appendix 3)

<u>Age, Length and Sex</u>

The age, length, and sex of the 1997 Harrison River spawning ground recoveries are reported in Appendix 4. The mean POH length of female, male, and jack chinook was 70.0 cm, 67.5 cm, and 46.3 cm, respectively. Fish identified in the field as jacks ranged in size from 33.5 to 52.5 cm POH while the smallest fish field-identified as a male was 52 cm and the smallest female was 56.5 cm. Of the aged samples, all fish had a sub1 juvenile growth pattern. Most females (54.0%) were age 4_1 while the majority of males (71.2%) were age 3_1. Of the 51 ageable fish identified in the field as jacks 26.1% (12) were aged as jacks. The majority (71.2%) was aged as age 3_1 and one fish was aged as an age 4_1 adult male (Appendix 4). No fish field-identified as adult male or female were aged as precocious. Within the field-identified jacks, there was a 10 cm overlap in POH lengths between fish aged as adult and those aged as precocious (Figure 4).

The age composition of AFC and unmarked carcasses was compared. A significant difference was observed only in females ($p < 0.05$; chi-square). None of the 687 carcasses examined for flesh colour had red flesh.

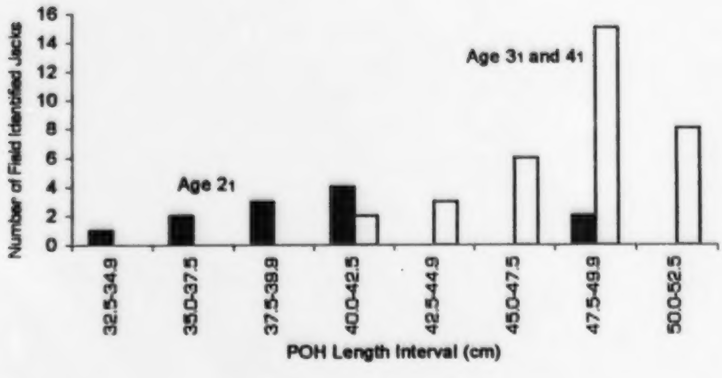

Figure 4. Post-orbital hypural length frequency distribution for chinook identified in the field as precocious males in the Harrison River, 1997.

Coded Wire Tag Recoveries

Thirty-one chinook had an AFC (Appendix 5). Three carcasses had questionable or partial AFCs and two carcasses had no head. CWTs were recovered from 24 heads (8 adult male, 16 female, and none in jacks), of which 13 (54.1%) were from 1993-brood, and 8 were from 1994-brood Chehalis River Hatchery releases. Three (12.5%) were from a 1994-brood Chehalis River Hatchery release at the Stave River. No CWTs were lost during processing and 5 (16.1%) of the heads did not contain a CWT. There was no significant difference ($p > 0.05$; chi-square) in CWT loss between carcasses with eyes versus those missing one or both eyes (Appendix 6) and no significant difference ($p > 0.05$; chi-square) in CWT loss between fresh and rotten carcasses. A significantly high absence of CWTs (100%) was observed in carcasses with questionable AFCs ($p < 0.05$; chi-square). Regardless of the possible influence of small sample size bias, the two carcasses with questionable clips were removed from calculations of CWT loss and AFC incidence.

There was no significant difference ($p > 0.05$; chi-square) in AFC incidence between the sexes (males 3.1% and females 5.4%) and the observed CWT loss rate was the same in both sexes (11.1%). There was no significant difference ($p > 0.05$; chi-square) in AFC incidence when the sex specific samples were stratified temporally. There was a significant difference ($p > 0.05$) in AFC incidence in males when the sample was stratified spatially with a high AFC incidence in the upper river section. Scale ageing accuracy was evaluated in 23 carcasses which both aged scales and CWTs were available. No ageing errors were noted.

SAMPLING SELECTIVITY

Period

Temporal bias in the application sample was examined by comparing mark incidences in three recovery periods (Table 4). Mark incidences in males and females showed no significant variation among the periods and both averaged 2.1%. Jacks showed greater variation (average 3.8%, range 0 to 10%) but the differences were not significant ($p > 0.05$; chi-square).

Table 4. Incidence of spaghetti tags or secondary marks in chinook salmon recovered on the Harrison River spawning grounds, by recovery period and sex, 1997. [a]

		Recovery Period			
		28-Oct to 09-Nov	10-Nov to 23-Nov	24-Nov to 03-Dec	Total
Recovered with spaghetti Tags or secondary marks	Male	6	34	9	49
	Female	7	31	9	47
	Jack	1	0	1	2
	Unknown	0	1	0	1
	Total	14	66	19	99
Carcasses examined	Male	359	1,429	603	2,391
	Female	323	1,326	600	2,249
	Jack	10	25	18	52
	Unknown	3	20	65	88
	Total	695	2,799	1,286	4,780
Mark Incidence	Male	1.7%	2.4%	1.5%	2.1%
	Female	2.2%	2.3%	1.5%	2.1%
	Jack	10.0%	0.0%	5.6%	3.8%
	Unknown	0.0%	5.0%	0.0%	1.1%
	Total	2.0%	2.4%	1.5%	2.1%

a. Excludes 11 recaptured chinook and 1 that required ventilation assistance at release.

Recovery bias was examined by comparing the recovery rate from four application periods (Table 5). The percentages ranged from 0% to 9.9%, with the highest average value in females (7.9%) and the lowest in jacks (1.0%). Within each sex group, the differences among periods were not significant ($p > 0.05$, chi-square).

Table 5. Percentage of the spaghetti tag application sample recovered on the Harrison River spawning grounds, by application period and sex, 1997. [a]

		Application Period				
		14-Oct to 18-Oct	19-Oct to 25-Oct	26-Oct to 01-Nov	01-Nov to 19-Nov	Total
Spaghetti tags Applied [b]	Male	205	326	260	147	938
	Female	90	161	191	103	545
	Jack	28	27	24	14	93
	Total	323	514	475	264	1,576
Spaghetti tags recovered	Male	9	13	9	5	36
	Female	7	16	14	6	43
	Jack	0	1	0	0	1
	Total [c]	16	30	24	11	81
Percent recovered	Male	4.4%	4.0%	3.5%	3.4%	3.8%
	Female	7.8%	9.9%	7.3%	5.8%	7.9%
	Jack	0.0%	3.7%	0.0%	0.0%	1.0%
	Total	5.0%	5.8%	5.1%	4.2%	5.1%

a. Excludes 220 recaptured fish and 3 that required ventilation assistance at release.

b. Corrected for sex identification error; rounding errors may be present.

c. Includes 1 of unknown sex in 26-Oct to01-Nov period.

Location

Spatial bias in the application sample was examined by comparing the mark incidences in three recovery sections (Table 6). In males, the highest mark incidence (2.4%) was in the lower section, but the differences were not significant. The mark incidences in females were significantly different ($p < 0.05$, chi-square). The highest female mark incidence (3.7%) was in the sample from the upper river section. After removal of this small sample from the upper section, the difference between the middle and lower sections was still significantly different (Table 6). Mark incidence in jack chinook was highest in the middle section, but the observed differences were not significant ($p > 0.05$; chi-square).

Table 6. Incidence of spaghetti tags or secondary marks in chinook salmon recovered on the Harrison River spawning grounds, by recovery section and sex, 1997. [a]

		Recovery Section [b]			
		Upper	Middle	Lower	Total
Recovered with spaghetti tags or secondary marks	Male	0	11	38	49
	Female	1	12	34	47
	Jack	0	1	1	2
	Unknown	0	1	0	1
	Total	1	25	73	99
Carcasses examined [c]	Male	18	806	1,566	2,390
	Female	27	1,030	1,187	2,244
	Jack	0	13	39	52
	Unknown	0	43	45	88
	Total	45	1,892	2,837	4,774
Mark Incidence	Male	0.0%	1.4%	2.4%	2.1%
	Female	3.7%	1.2%	2.9%	2.1%
	Jack	-	7.7%	2.6%	3.8%
	Unknown	-	2.3%	0.0%	1.1%
	Total	2.2%	1.3%	2.6%	2.1%

a. Excludes 11 recaptured fish and 1 that required ventilation assistance at release.
b. Upper - reaches 1 and 2; Middle - reaches 3,4, and 5; and Lower - reaches 6,7, and 8.
c. Excludes 6 carcasses from unreported recovery section.

Recovery bias was examined by stratifying the application sample into three reaches and comparing percentages recovered from each stratum (Table 7). Only 4 marks were applied in Reach 4. Within reaches 2 and 3, the percentages recovered ranged from 0.0% to 11.0%. The higher recovery in males was from marks applied in reach 2, while female recovery was highest from marks applied in reach 3. The differences observed were not significant ($p > 0.05$, chi-square).

Table 7. Proportion of the spaghetti tag application sample recovered on the Harrison River spawning grounds, by application reach and sex, 1997. [a]

		Application reach			
		Reach 2	Reach 3	Reach 4	Total
Spaghetti tags Applied [b]	Male	837	101	0	938
	Female	488	55	1	545
	Jack	76	14	3	93
	Total	1,402	170	4	1,576
Spaghetti tags recovered	Male	34	2	0	36
	Female	37	6	0	43
	Jack	1	0	0	1
	Total [c]	73	8	0	81
Percent recovered	Male	4.1%	2.0%	-	3.8%
	Female	7.6%	10.9%	0.0%	7.9%
	Jack	1.3%	0.0%	0.0%	1.0%
	Total	5.2%	4.7%	0.0%	5.1%

a. Excludes 220 recaptured fish and 3 that required ventilation assistance at release.
b. Corrected for sex identification error; rounding errors may be present.
c. Includes 1 of unknown sex in reach 2.

Fish Size

Size related bias in the application sample was examined by comparing the POH length frequency distributions of marked and unmarked spawning ground recoveries. No significant differences ($p > 0.05$; Kolmogorov-Smirnov two sample test) were detected in females, adult males, or jacks. Mark incidences in 10 cm POH length intervals are presented in Table 8.

Recovery sample bias was examined by partitioning the application sample into recovered and non-recovered components and comparing NF length frequency distributions. There was no significant difference ($p > 0.05$, Kolmogorov-Smirnov two sample test) in any of the sex groups. Percentage recovery in 10 cm NF length intervals are presented in Table 9.

Table 8. Incidence of spaghetti tags or secondary marks in Harrison River chinook carcass sample recovered on the spawning grounds, by 10 cm increments of post-orbital-hypural length and sex, 1997. [a]

	Carcasses sampled			Marked carcasses			Mark incidence		
POH Length (cm)	Male	Female	Jack	Male	Female	Jack	Male	Female	Jack
30-39.9	0	0	5	0	0	0	-	-	0.0%
40-49.9	0	0	31	0	0	2	-	-	6.5%
50-59.9	45	9	14	8	3	0	17.8%	33.3%	0.0%
60-69.9	124	168	0	26	28	0	21.0%	16.7%	-
70-79.9	92	145	0	10	12	0	10.9%	8.3%	-
80-89.9	15	19	0	2	3	0	13.3%	15.8%	-
90-99.9	2	2	0	0	0	0	0.0%	0.0%	-

a. Excludes carcasses not measured for POH length, 11 fish recaptured during mark application and 1 fish that required ventilation assistance at release.

Table 9. Percentage of the Harrison River chinook salmon spaghetti tag application sample recovered on the spawning grounds, by 10 cm increments of nose-fork length and sex, 1997. [a]

	Tags applied [b,c]			Recovered with Tag			Percentage recovered		
Nose-fork length (cm)	Male	Female	Jack	Male	Female	Jack	Male	Female	Jack
30-39.9	0	0	1	0	0	0	-	-	0.0%
40-49.9	0	0	22	0	0	0	-	-	0.0%
50-59.9	0	0	30	0	0	0	-	-	0.0%
60-69.9	63	16	40	5	1	2	8.3%	5.3%	5.0%
70-79.9	245	152	0	10	11	0	4.1%	6.8%	-
80-89.9	410	265	0	17	22	0	4.3%	7.9%	-
90-99.9	183	98	0	3	8	0	1.7%	7.6%	-
100-109.9	34	13	0	0	2	0	0.0%	14.3%	-
110-119.9	2	0	0	0	0	0	0.0%	-	-

a. Excludes 220 recaptured fish and 3 that required ventilation assistance at release.
b. Corrected for sex identification error; rounding error may be present.
c. Excludes 2 for which no length recorded.

Fish Sex

There was no significant difference ($p > 0.05$; chi-square) in the sex ratio of the marked and unmarked spawning ground recoveries (Table 10). The application sample, therefore, was not significantly biased. There was a significant difference ($p < 0.05$; chi-square) in the sex ratio of the recovered and non-recovered components of the application sample (Table 10) indicating that the recovery sample was biased to females. In addition, there were significant differences noted among the recovery rates of adult males (5.2%), females (8.6%), and jacks (2.2%) ($p < 0.05$; chi-square) (Table 3). The recovery rates in adult and precocious males were not significantly different.

Table 10. Sex composition of Harrison River chinook salmon in the spaghetti tag application and spawning ground recovery samples, 1997. [a]

	Application sample [b]			Recovery sample		
Sex	Sample size	Recovered [c]	Not recovered	Sample size [d]	Marked [c]	Unmarke
Male	938	50.0%	60.1%	2,391	50.0%	51.0
Female	545	48.0%	33.7%	2,249	48.0%	47.9
Jack	93	2.0%	6.2%	52	2.0%	1.1
Total	1,576	100.0%	100.0%	4,692	100.0%	100.0%

a. Excludes 220 recaptured fish and 3 that required ventilation assistance at release.
b. Corrected for sex identification error; rounding errors may be present.
c. Excludes 1 fish of unknown sex.
d. Excludes 88 fish of unknown sex.

Recovery Depth

Bias resulting from recovery in different water depths was assessed by comparing the mark incidence in the sampled carcasses from deep (gaffed) and shallow water (on or near beach) areas (Table 11). Only marked fish and those fish sampled for length, sex, age and other factors (14.5% of carcasses) had the depth of recovery recorded. Mark incidence in the deep area was consistently lower than in the shallow area; however, there was no significant difference in any of the sex groups. The mark incidence (3.8%) in shallow water jacks was significantly lower than that in adult males and females ($p < 0.05$; chi-square). There was no significant difference between the mark incidences in female and adult male carcasses in either of the recovery depths.

To assess size bias associated with the two recovery methods the POH length frequency distributions of carcasses from the deep and shallow water recovery areas were compared. No significant differences were noted in any of the sex groups ($p > 0.05$, Kolmogorov-Smirnov two sample test) (Table 12).

Table 11. Incidence of spaghetti tags or secondary marks in chinook salmon carcasses recovered on the Harrison River spawning grounds, by depth of water in the recovery area, 1997. [a]

	Sex	Depth of water		
		Shallow [a]	Deep	Unknown
Recovered with spaghetti tags or secondary marks	Male	47	2	0
	Female	45	2	0
	Unknown	1	0	0
	Jack	2	0	0
Carcasses recovered [b]	Male	259	29	1
	Female	325	28	0
	Unknown	1	0	0
	Jack	51	1	0
Mark Incidence	Male	18.1%	6.9%	0.0%
	Female	13.8%	7.1%	-
	Unknown	100.0%	-	-
	Jack	3.9%	0.0%	-

a. Excludes 11 recaptured fish and 1 that required ventilation assistance at release.
b. Sampled carcasses only.

Table 12. Length frequency distribution in Harrison River chinook recovered in shallow and deep areas of the spawning grounds, by 10 cm increments of post-orbital hypural length and sex, 1997.

	Shallow water			Deep water			Percentage Deep		
POH length (cm)	Male	Female	Jack	Male	Female	Jack	Male	Female	Jack
30-39.9	0	0	5	0	0	0	-	-	0.0%
40-49.9	0	0	30	0	0	0	-	-	0.0%
50-59.9	42	8	14	5	1	0	10.6%	11.1%	0.0%
60-69.9	110	158	0	12	10	0	9.8%	6.0%	-
70-79.9	91	132	0	10	14	0	11.0%	9.6%	-
80-89.9	14	18	0	1	1	0	6.7%	5.3%	-
90-99.9	2	1	0	0	1	0	0.0%	50.0%	-

a. Excludes carcasses not sampled and not measured for length.
b. Excludes 11 recaptured fish and 1 fish that required ventilation assistance at release.

Spawning Success

Spawning success, estimated from the internal examination of female spawning ground recoveries, was estimated at 97.0% (Appendix 7). The spawning success of marked (95.7%) and unmarked (97.2%) females was not significantly different ($p > 0.05$; chi-square).

ESTIMATION OF SPAWNER POPULATION

While serious spatial and temporal biases were not identified in this study, there were significant sex related biases identified (Table 13). Therefore, it was necessary to calculate the escapement by sex.

Table 13. Results of statistical tests for bias in the 1997 Harrison River chinook salmon escapement estimation study. [a]

Bias type	Application sample	Recovery sample
Statistical [b]	n/a	No bias
Period	No bias	No bias
Location	Bias in females to lower section	No bias
Fish size	No bias	No bias
Fish sex	No bias	Bias toward females
Recovery method	n/a	No bias

a. No bias indicates that bias was not detected; undetected bias may be present.
b. Bias present when recoveries total 4 or less.

The 1997 escapement of Harrison River chinook salmon, calculated as the sum of the Petersen estimators for each sex, was estimated at 74,096 (Table 14), with lower and upper 95% confidence limits of 59,360 and 88,832. The male escapement was 48,503 ± 12,919 of which 1,819 were identified by scale ageing as jacks. The female escapement was estimated to total 25,593 ± 7,089 chinook. The jack estimate has been derived from scale ageing results rather than length criteria because of observed overlap in lengths between adult and precocious males, the statistical bias in the Petersen jack estimate, and the magnitude of the confidence limits around the Petersen jack estimate. We concluded that these factors resulted in imprecision and inaccuracies in the jack Petersen estimate and recommend that future estimates of jack population be based on application of scale ageing results to the estimated total male escapement. We have recalculated the 1996 estimates to reflect this change in approach (Table 14).

Based on the application of the age composition data to the Petersen estimates, the escapement contained 1,819 age 2_1, jack chinook, and 44,795 age 3_1, 24,589 age 4_1, and 2,892 age 5_1 chinook. Based on the pooled AFC incidence (4.3%) in the recovery sample adjusted for carcasses with questionable AFCs (Appendices 5 and 6), the 1997 escapement estimate included 3,186 AFC adults. There were no AFCs observed in field-identified jacks and no age 2_1 CWTs. Escapement by CWT code was not estimated because sample size was insufficient to warrant stratification of the AFC sample by age and sex.

Table 14. Annual escapement estimates and 95% confidence limits, by sex and age, for Harrison River chinook salmon, 1984-1997. [a]

Sex	Year	Escapement at Age							Total	95% confidence limit on total escapement	
		2_1	3_1	4_1	4_2	5_1	5_2	6_1		Lower	Upper
Male	1984	n/a	38,688	30,764	0	2,797	0	0	72,249	55,457	89,042
	1985	n/a	47,771	59,236	0	7,643	0	0	114,650	78,343	150,957
	1986	n/a	4,907	76,407	0	3,505	0	0	84,819	64,336	105,302
	1987	n/a	10,910	24,374	0	5,803	0	0	41,088	33,166	49,011
	1988	n/a	1,828	14,473	0	1,524	0	0	17,825	13,533	22,117
	1989	n/a	34,566	11,522	0	4,389	0	0	50,478	36,652	64,304
	1990	n/a	3,832	98,361	0	2,555	0	0	104,748	72,116	137,380
	1991	n/a	21,761	17,921	0	8,320	0	0	48,002	33,818	62,186
	1992	n/a	25,820	50,164	0	1,107	0	0	77,090	58,585	95,595
	1993	n/a	26,693	21,354	0	3,003	0	0	51,050	39,372	62,727
	1994	n/a	2,965	49,740	0	2,306	0	329	55,340	41,683	68,997
	1995	n/a	7,093	5,320	0	3,842	0	0	16,255[b]	n/a	n/a
	1996c	6,076	18,663	18,663	0	1,302	0	0	44,705	33,993	55,417
	1997	1,819	34,558	10,762	0	1,364	0	0	48,503	35,584	61,422
Female	1984	0	11,062	32,754	0	4,772	0	0	48,588	37,881	59,296
	1985	0	12,248	43,426	557	3,897	0	0	60,128	46,951	73,304
	1986	0	759	73,224	0	3,794	0	0	77,777	65,683	89,872
	1987	0	782	26,115	0	11,052	0	0	37,950	33,560	42,341
	1988	0	418	14,990	70	1,743	0	70	17,291	14,222	20,361
	1989	0	13,364	7,565	252	3,026	0	0	24,207	16,638	32,907
	1990	0	1,391	69,844	0	1,391	0	0	72,627	60,273	84,981
	1991	0	8,066	23,046	0	11,523	0	0	42,636	28,641	56,631
	1992	0	4,963	46,165	0	2,193	0	0	53,321	43,041	63,601
	1993	0	18,552	44,033	224	5,141	0	0	67,949	55,024	80,873
	1994	0	765	40,997	0	956	96	191	43,004	37,101	48,907
	1995	0	3,153	5,676	0	3,532	0	0	12,361	5,677	19,045
	1996	0	3,696	13,985	0	499	0	0	18,180	14,425	21,935
	1997	0	10,237	13,828	0	1,528	0	0	25,593	18,504	32,682
Total	1984	n/a	49,751	63,518	0	7,569	0	0	120,837	100,921	140,752
	1985	n/a	60,019	102,662	557	11,541	0	0	174,778	136,153	213,402
	1986	n/a	5,666	149,631	0	7,299	0	0	162,596	138,811	186,385
	1987	n/a	11,693	50,489	0	16,856	0	0	79,038	69,981	88,096
	1988	n/a	2,247	29,463	70	3,267	0	70	35,116	29,839	40,392
	1989	n/a	47,931	19,087	252	7,415	0	0	74,685	58,737	90,663
	1990	n/a	5,224	168,205	0	3,946	0	0	177,375	142,483	212,268
	1991	n/a	29,827	40,967	0	19,844	0	0	90,638	70,712	110,564
	1992	n/a	30,782	96,329	0	3,299	0	0	130,411	109,242	151,580
	1993	n/a	45,244	65,387	224	8,144	0	0	118,998	101,580	136,417
	1994	n/a	3,729	90,738	0	3,261	96	521	98,344	83,466	113,223
	1995	n/a	10,246	10,996	0	7,374	0	0	28,616	n/a	n/a
	1996c	6,076	22,359	32,648	0	1,802	0	0	62,885	51,534	74,236
	1997	1,819	44,795	24,589	0	2,892	0	0	74,096	59,360	88,832

a. Rounding errors may be present.

b. Derived by application of average male:female ratio to female estimate (Farwell et al. 1998)

c. Revised estimates. Farwell et al (1999) estimates corrected to reflect change in jack escapement calculation method (see text).

DISCUSSION

SAMPLING SELECTIVITY

Population estimates derived from mark-recovery studies are susceptible to bias from a number of sources, including: tag loss; physiological stress which can induce emigration of tagged fish from the population, affect subsequent behaviour, or alter recovery vulnerability; and non-representative tag application or mark recovery resulting from samples which are too small, or are selective by fish size, sex, or spatial and temporal run component.

Tag loss was anticipated and accounted for by applying a secondary mark to all spaghetti tagged fish. Physiological stress during marking was minimized by using a low stress handling technique described by Staley (1990); however, this method still results in stress on the fish. The effects of handling stress were evident in those fish that underwent recapture episodes. There was a significantly different mark recovery rate in males and females that had been recaptured one or more times after initial mark application than that in fish which were not recaptured. Recaptured males were recovered at a higher rate than non-recaptured males while recaptured females showed a lower recovery rate. These apparent differences in behaviour within the recapture group could bias the escapement estimates and all recaptured fish were removed from the mark-recovery calculations and from further bias testing. The existence of recaptures and the absence of tags reported from outside of the study area indicates that the study area was closed to emigration. To evaluate the effect of handling stress on subsequent spawning behaviour, we compared spawning success in spaghetti tagged and untagged females. No significant difference was noted. These results are consistent with those in past studies (Farwell et al. 1996, 1999). We concluded, therefore, that the initial capture and marking did not significantly influence subsequent behaviour but that the additional stress associated with subsequent recapture and release can alter the recovery vulnerability of recaptured marked chinook.

It was not possible to definitively test the true representativeness of the application and recovery samples because the actual population parameters were not known. Instead, we examined the two samples for five biases: statistical, temporal, spatial, fish size and fish sex, which may be indicative of weakness in the study design.

A significant bias to females was identified in the recovery sample. This bias in conjunction with the significant difference in recovery rates between males and females necessitated the calculation of escapement estimates by sex. There was a spatial bias observed in females which showed a higher mark incidence in the lower river reaches. This, in conjunction with the observation that recaptured females showed a lower recovery rate, may indicate that mark application stress caused marked females to redistribute themselves further downstream than unmarked females. There was no spatial bias detected in the recovery sample; therefore, spatially stratified calculation of escapement was not necessary.

The observation of significant overlap in size between jacks and adult males indicates that there may be some age related bias within the male escapement estimate. Although, the jack escapement estimate derived from application of the age composition to

the pooled male mark-recovery data (1,819) was similar to the estimate derived as described in the methods section (1,660), there was significant imprecision in the jack Petersen estimate ($\pm$ 95% of estimate in 1997 and $\pm$ 61% in the 1996 jack estimate). We suggest that, because the errors in field determination of age from fork length or POH length appear to be significant, that there may be little advantage to estimating the age of males in the field. In future, we recommend that the identification of precocious males and the calculation of jack escapement should be derived from scale readings and not based on length criteria, known to be inaccurate.

SUMMARY

The Harrison River chinook stock is one of a group of British Columbia chinook stocks being monitored to evaluate escapement responses to management actions implemented under the Pacific Salmon Treaty.

Spawners were enumerated by a mark-recovery study from October 14 to December 3, 1997. Chinook adults and precocious males were captured using a beach seine and marked with spaghetti tags and opercular punches. A census of the marks was obtained from the recovery of carcasses following spawning.

The 1997 chinook escapement was estimated from a spaghetti tag application sample of 1,480 adults and 96 jacks and a recovery sample of 4,640 adults and 52 jacks containing 96 adult and 2 jack carcasses with spaghetti tags or secondary marks. The escapement estimate was 74,096 chinook.

Within the sampled portion of the recovery sample, the dominant age class was age 4_1 (54.0%) in the females while age 3_1 fish were predominant (71.2% each) in males. POH length averaged 67.5 cm for adult males, 70.0 cm for females and 46.3 cm for jacks.

A sex based bias was observed within the recovery sample. In addition, a spatial bias was present in females in the application sample. Field identified jacks showed a low recovery rate in beach recovered carcasses; however, this may be a statistical bias related to small sample size. The basic assumptions underlying the Petersen mark-recovery technique were not seriously violated and the spawning escapement estimates are not significantly biased. Scale age results confirm that the overlapping sizes of adult and precocious males results in inaccuracies of field-identification of jack chinook. Jack escapement estimation has been based on age composition to avoid inaccuracies and imprecision. The 1996 data have been amended to reflect this change in methodology.

Harrison River escapement has averaged 104,178 over the 1984-1996 study period. The 1997 estimate, the fourth lowest on record, was 29% below average. The annual escapement pattern over those years, although statistically insignificant, is downward.

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APPENDICES

Appendix 1. Daily application of spaghetti tags and secondary marks, by reach, adipose fin status, and sex to chinook salmon; and daily recaptures of previously marked chinook salmon, by sex, captured and released during subsequent mark application in the Harrison River, 1997. a

		Adipose present				Adipose absent				Total				Recaptures f			
Date	Reach	Male	Female	Jack	Total	Male	Female	Jack	Total	Male	Female	Jack	Total	Male	Female	Jack	Total
14-Oct	2	22 g	6	5	33	0	0	0	0	22	6	5	33	0	0	0	0
15-Oct	2	58	31	13	102	1	0	0	1	59	31	13	103	4	7	2	13
16-Oct	2	42	31	8	81	0	0	0	0	42	31	8	81	6	10	7	23
16-Oct	3	11	3	3	17	0	0	0	0	11	3	3	17	0	0	0	0
17-Oct	2	87 g	49	9	145	0	1	0	1	87	50	9	146	11	12	3	26
20-Oct	2	110	64	13 g	187	1	1	0	2	111	65	13	189	10	10	7	27
21-Oct	2	79	42	8	129	1	1	0	2	80	43	8	131	8	5	1	14
22-Oct	2	43	24 g	2	69	0	0	0	0	43	24	2	69	2	4	1	7
22-Oct	3	2 g	1	0	3	0	0	0	0	2	1	0	3	0	0	0	0
23-Oct	2	55	33	5	93	0	0	0	0	55	33	5	93	8	7	0	15
24-Oct	2	53 b,h	32 g	2	87	1	1	0	2	54	33	2	89	9	7	1	17
27-Oct	2	92	82 c	7	181	0	1	0	1	92	83	7	182	6	17	1	24
28-Oct	2	98	82 c	9	189	0	2	0	2	99	84	9	192	25	27	0	52
29-Oct	2	5	8	1	14	0	0	0	0	5	8	1	14	1	0	0	1
29-Oct	3	64	44	7	115	1	0	0	1	65	44	7	116	8	3	1	12
31-Oct	2	13	14 d	0	27	0	0	0	0	13	14	0	27	3	3	0	6
31-Oct	3	8	8	2	18	0	1	0	1	8	9	2	19	2	7	0	9
03-Nov	2	20 c	19	3	42	1	0	0	1	21	19	3	43	2	3	0	5
03-Nov	3	13	4	1	18	0	0	0	0	13	4	1	18	0	3	0	3
03-Nov	4	0	1	3	4	0	0	0	0	0	1	3	4	0	0	0	0
04-Nov	2	60 g	43 g	4	107	0	1	0	1	60	44	4	108	12	8	2	22
05-Nov	2	51 g	33	1	85	0	0	0	0	51	33	1	85	13	10	0	23
06-Nov	2	10	9	0	19	0	0	0	0	10	9	0	19	0	1	0	1
07-Nov	2	0	1	0	1	0	0	0	0	0	1	0	1	0	0	0	0
10-Nov	2	0	1	0	1	0	0	0	0	0	1	0	1	0	0	0	0
12-Nov	3	4 d	6	2	12	1	0	0	1	5	6	2	13	0	0	0	0
19-Nov	2	1	0	0	1	0	0	0	0	1	0	0	1	1	0	0	1
19-Nov	3	0	0	1	1	0	0	0	0	1	0	1	2	0	0	0	0
Total	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	899	604	90	1,593	5	8	0	13	905	612	90	1,607	121	131	25	277
	3	102	66	16	184	2	1	0	3	105	67	16	188	10	13	1	24
	4	0	1	3	4	0	0	0	0	0	1	3	4	0	0	0	0
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	1,001	671	109	1,781	7	9	0	16	1,010	680	109	1,799	131	144	26	301

a. Not corrected for se[illegible] errors.

b. Includes 1 for which secondary mark was not recorded.

c. Includes 1 which required ventilation at release.

d. Includes 1 for which nose-fork length was not recorded.

e. Includes 1 for which adipose status was not recorded.

f. Includes multiple recaptures of individual fish.

g. Includes 1 for which release condition was not recorded.

h. Includes 3 for which release condition was not recorded.

Appendix 2. Spaghetti tag and secondary mark recoveries, by application and recovery date and location, size, sex, adipose fin status, tag number and age, from chinook salmon in the Harrison River, 1997.

Application sample							Recovery sample					
Date	Reach	Fork length (cm)	Sex	Adipose fin	Spaghetti tag number		Date	Reach	POH length (cm)	Sex	Age	Days out
22-Oct	3	69.0	F	P	M 2349		11-Nov	6	57.0	F		20
14-Oct	2	84.0	M	P	M 2508		18-Nov	6	67.0	M		35
14-Oct	2	79.0	M	P	M 2528		17-Nov	8	65.0	M		34
15-Oct	2	89.0	F	P	M 2541	a	10-Nov	8	70.0	F		26
15-Oct	2	69.0	M	P	M 2552		28-Oct	7	56.0	M		13
15-Oct	2	96.0	M	P	M 2587		21-Nov	8	75.0	M		37
16-Oct	2	87.0	M	P	M 2663		17-Nov	7	70.0	M		32
16-Oct	2	72.0	F	P	M 2669		5-Nov	7	62.0	F		20
16-Oct	2	77.0	F	P	M 2683		17-Nov	7	68.0	F		32
16-Oct	2	83.0	F	P	M 2695		11-Nov	7	67.5	F		26
16-Oct	2	72.0	F	P	M 2712	a	17-Nov	8	61.0	F		32
16-Oct	2	85.0	F	P	M 2713		20-Nov	4	68.0	F		35
16-Oct	2	73.0	F	P	M 2715	a	11-Nov	7	61.0	F		26
16-Oct	2	92.0	M	P	M 2718	a	10-Nov	8	71.0	M		25
17-Oct	2	82.0	F	P	M 2753		18-Nov	6	65.0	F		32
17-Oct	2	81.0	M	P	M 2767		19-Nov	4	64.0	M		33
17-Oct	2	80.5	M	P	M 2784		12-Nov	4	62.0	M		26
17-Oct	2	78.0	F	P	M 2808		25-Nov	4	63.5	F		39
17-Oct	2	68.0	M	P	M 2820	a	25-Nov	4	49.5	J		39
17-Oct	2	78.0	F	P	M 2826		17-Nov	7	64.5	F		31
17-Oct	2	84.0	M	P	M 2847	a	18-Nov	5	64.0	M		32
17-Oct	2	92.0	M	P	M 2871		5-Nov	7	75.0	M		19
17-Oct	2	73.0	M	P	M 2881		21-Nov	8	57.5	M		35
20-Oct	2	103.0	F	P	M 2889		5-Nov	7	82.5	F		16
20-Oct	2	89.0	M	P	M 2910		18-Nov	7	71.0	M		29
20-Oct	2	68.0	M	P	M 2922		25-Nov	4	53.0	M		36
20-Oct	2	64.5	J	P	M 2962		5-Nov	7	52.5	M		16
20-Oct	2	75.0	M	P	M 2963		6-Nov	6	65.5	M		17
20-Oct	2	91.0	F	P	M 2974		6-Nov	6	74.0	F		17
20-Oct	2	83.0	F	P	M 2984		10-Nov	8	66.5	F		21
20-Oct	2	93.0	M	P	M 3010	a	26-Nov	5	67.0	M		37
20-Oct	2	84.0	M	P	M 3013		11-Nov	6	76.0	M		22
20-Oct	2	69.0	M	P	M 3053		11-Nov	6	60.0	M		22
20-Oct	2	96.0	F	P	M 3056		17-Nov	8	80.0	F		28
21-Oct	2	88.0	M	P	M 3079		19-Nov	6	68.0	M		29
21-Oct	2	84.0	F	P	M 3090		3-Nov	1	68.0	F		13
21-Oct	2	74.0	M	P	M 3116		21-Nov	8	60.0	M		31
21-Oct	2	85.0	F	P	M 3122		19-Nov	6	70.0	F		29
21-Oct	2	84.0	M	P	M 3124	a	11-Nov	7	64.5	M		21
21-Oct	2	86.0	F	P	M 3125		1-Dec	8	69.0	F		41
21-Oct	2	91.0	F	P	M 3144		11-Nov	7	75.0	F		21

Appendix 2. Spaghetti tag and secondary mark recoveries, by application and recovery date and location, size, sex, adipose fin status, tag number and age, from chinook salmon in the Harrison River, 1997.

Application sample						Recovery sample					
Date	Reach	Fork length (cm)	Sex	Adipose fin	Spaghetti tag number	Date	Reach	POH length (cm)	Sex	Age	Days out
21-Oct	2	80.0	F	P	M 3199	18-Nov	6	65.0	F		28
22-Oct	2	81.0	F	P	M 3211	11-Nov	7	67.3	F		20
22-Oct	2	62.0	J	P	M 3215	24-Nov	6	49.0	J		33
22-Oct	2	69.0	M	P	M 3232	17-Nov	8	54.5	M		26
22-Oct	2	68.0	M	P	M 3233	17-Nov	8	51.0	M		26
22-Oct	2	88.0	M	P	M 3234	20-Nov	4	68.0	M		29
22-Oct	2	74.0	F	P	M 3240	6-Nov	6	62.0	F		15
22-Oct	2	80.0	F	P	M 3251	21-Nov	7	62.0	F		30
22-Oct	2	90.0	F	P	M 3265	7-Nov	4	72.0	F		16
23-Oct	2	89.0	F	P	M 3278	11-Nov	7	68.0	F		19
23-Oct	2	99.0	M	P	M 3348	11-Nov	4	80.0	M		19
23-Oct	2	84.0	M	P	M 3350	5-Nov	7	66.0	M		13
24-Oct	2	87.0	F	P	M 3420	17-Nov	8	70.0	F		24
24-Oct	2	86.5	M	P	M 3425 a	5-Nov	7	68.0	M		12
27-Oct	2	90.0	F	P	M 3474 b	11-Nov	7	71.0	F		15
27-Oct	2	101.0	F	P	M 3487	25-Nov	4	78.4	F		29
27-Oct	2	89.0	M	P	M 3512	26-Nov	8	73.0	M		30
27-Oct	2	79.0	M	P	M 3515	27-Nov	8	64.0	M		31
27-Oct	2	76.0	M	P	M 3594	17-Nov	7	60.0	M		21
27-Oct	2	92.0	F	P	M 3606	19-Nov	6	73.0	F		23
28-Oct	2	84.0	F	P	M 3660 a	27-Nov	6	69.0	F		30
28-Oct	2	82.0	F	P	M 3677	21-Nov	8	68.5	F		24
28-Oct	2	80.0	M	P	M 3681	25-Nov	4	64.3	M		28
28-Oct	2	91.0	F	P	M 3709	12-Nov	5	77.0	NR		15
28-Oct	2	84.0	F	P	M 3727	24-Nov	7	71.0	F		27
28-Oct	2	81.0	M	P	M 3733	11-Nov	7	63.5	M		14
28-Oct	2	87.0	F	P	M 3761	18-Nov	6	69.0	F		21
28-Oct	2	80.0	M	P	M 3762	1-Dec	7	63.0	M		34
28-Oct	2	79.0	F	P	M 3767	18-Nov	6	66.0	F		21
28-Oct	2	79.0	F	P	M 3778 a	11-Nov	7	63.0	F		14
28-Oct	2	73.0	M	P	M 3818	18-Nov	7	61.0	M		21
28-Oct	2	80.0	F	P	M 3823	19-Nov	6	64.0	F		22
28-Oct	2	87.0	F	P	M 3827	26-Nov	8	82.0	F		29
28-Oct	2	84.0	F	P	M 3834	18-Nov	6	69.0	F		21
29-Oct	2	80.0	F	P	M 3837	25-Nov	4	65.0	M		27
29-Oct	3	96.0	F	P	M 3865	24-Nov	4	78.9	F		26
29-Oct	3	74.0	M	P	M 3893	17-Nov	8	56.0	M		19
29-Oct	3	86.0	F	P	M 3895	12-Nov	5	70.0	F		14
29-Oct	3	82.0	F	P	M 3915	7-Nov	4	67.0	F		9
29-Oct	3	98.0	F	P	M 3937	21-Nov	8	75.0	F		23
31-Oct	3	70.0	F	P	M 3972	21-Nov	8	56.3	F		21

Appendix 2. Spaghetti tag and secondary mark recoveries, by application and recovery date and location, size, sex, adipose fin status, tag number and age, from chinook salmon in the Harrison River, 1997.

Application sample						Recovery sample					
Date	Reach	Fork length (cm)	Sex	Adipose fin	Spaghetti tag number	Date	Reach	POH length (cm)	Sex	Age	Days out
3-Nov	2	84.0	M	P	M 4016	20-Nov	4	65.0	M		17
3-Nov	3	82.0	M	P	M 4025	18-Nov	7	66.0	M		15
3-Nov	2	76.0	F	P	M 4079	25-Nov	4	66.0	F		22
4-Nov	2	70.0	M	P	M 4134	17-Nov	7	55.5	M		13
4-Nov	2	78.0	F	P	M 4136	26-Nov	5	63.0	F		22
4-Nov	2	70.0	M	P	M 4169	21-Nov	8	58.3	F		17
4-Nov	2	75.0	F	P	M 4185	19-Nov	6	62.0	F		15
4-Nov	2	83.0	M	P	M 4193	21-Nov	8	66.5	M		17
5-Nov	2	84.5	M	P	M 4262	18-Nov	6	67.0	M		13
6-Nov	2	78.0	F	P	M 4289	18-Nov	6	-	F		12
6-Nov	2	84.0	F	P	M 4295	27-Nov	6	69.0	F		21
Primary tag lost; application data unknown						7-Nov	4	48.0	J		-
Primary tag lost; application data unknown						7-Nov	4	69.0	M		-
Primary tag lost; application data unknown						11-Nov	4	64.3	F		-
Primary tag lost; application data unknown						11-Nov	7	83.5	M		-
Primary tag lost; application data unknown						11-Nov	4	75.8	F		-
Primary tag lost; application data unknown						11-Nov	4	66.4	M		-
Primary tag lost; application data unknown						11-Nov	4	65.0	F		-
Primary tag lost; application data unknown						12-Nov	4	67.0	M		-
Primary tag lost; application data unknown						17-Nov	7	71.0	M		-
Primary tag lost; application data unknown						17-Nov	7	78.0	M		-
Primary tag lost; application data unknown						17-Nov	8	65.0	F		-
Primary tag lost; application data unknown						18-Nov	6	63.0	M		-
Primary tag lost; application data unknown						18-Nov	6	61.0	M		-
Primary tag lost; application data unknown						18-Nov	7	73.0	M		-
Primary tag lost; application data unknown						19-Nov	6	77.0	M		-
Primary tag lost; application data unknown						24-Nov	7	65.0	M		-
Primary tag lost; application data unknown						27-Nov	6	70.0	M		-
Primary tag lost; application data unknown						1-Dec	8	62.3	M		-

Females initially identified as males:	1	2.0%
Males initially identified as females:	2	4.9%
Jacks initially identifed as males:	1	2.4%

Mean days out:	24.0
Max. days out:	41.0
Min. days out:	9.0

POH and NF Regressions:				
	Females	POH =	0.69NF + 10.18	r^2 = 0.84
		NF =	1.21POH + 0.99	
	Males	POH =	0.77NF + 1.93	r^2 = 0.85
		NF =	1.10POH + 10.28	

Appendix 2. Spaghetti tag and secondary mark recoveries, by application and recovery date and location, size, sex, adipose fin status, tag number and age, from chinook salmon in the Harrison River, 1997.

Application sample						Recovery sample					
Date	Reach	Fork length (cm)	Sex	Adipose fin	Spaghetti tag number	Date	Reach	POH length (cm)	Sex	Age	Days out
			Jacks	only two data points - included in male data.							

a. Recaptured and released during mark application period.

b. Required ventilation assistance at release.

Appendix 3. Daily chinook salmon carcass recoveries, by reach, mark status and sex, in the Harrison River, 1997.

		Unmarked				Spagetti tag and secondary mark			Secondary mark only			Spagetti tag only			Total				Adipose fin absent	
Date	Reach	Male	Female	Unknown sex	Jack	Male	Female	Jack	Male	Female	Jack	Male	Female	Unknown sex	Male	Female	Unknown sex	Jack	Male	Female
28-Oct	7	28	12	1	3	1	0	0	0	0	0	0	0	0	29	12	1	3	1	1
30-Oct	7	10	12	0	0	0	0	0	0	0	0	0	0	0	10	12	0	0	1	1
30-Oct	8	4	4	0	0	0	0	0	0	0	0	0	0	0	4	4	0	0	0	0
31-Oct	5	6	4	0	0	0	0	0	0	0	0	0	0	0	6	4	0	0	0	0
31-Oct	6	13	13	0	0	0	0	0	0	0	0	0	0	0	13	13	0	0	0	0
31-Oct	7	11	12	0	0	0	0	0	0	0	0	0	0	0	11	12	0	0	0	0
03-Nov	1	0	8	0	0	0	1	0	0	0	0	0	0	0	0	9	0	0	0	0
03-Nov	4	37	32	0	1	0	0	0	0	0	0	0	0	0	37	32	0	1	0	0
04-Nov	3	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
04-Nov	4	2	8	0	0	0	0	0	0	0	0	0	0	0	2	8	0	0	0	0
04-Nov	8	7	5	0	0	0	0	0	0	0	0	0	0	0	7	5	0	0	0	0
05-Nov	7	68	41	0	2	4 a	1	0	0	0	0	0	1	0	72	43	0	2	0	0
06-Nov	6	89	56	0	1	1	2	0	0	0	0	0	0	0	90	58	0	1	0	0
07-Nov	4	54	76	2	2	0	2	0	1	0	1	0	0	0	55	78	2	3	0	0
07-Nov	5	24	31	0	0	0	0	0	0	0	0	0	0	0	24	31	0	0	0	0
10-Nov	1	5	6	0	0	0	0	0	0	0	0	0	0	0	5	6	0	0	0	0
10-Nov	2	6	6	0	0	0	0	0	0	0	0	0	0	0	6	6	0	0	1	0
10-Nov	3	2	7	0	0	0	0	0	0	0	0	0	0	0	2	7	0	0	0	1
10-Nov	7	14	6	0	0	0	0	0	0	0	0	0	0	0	14	6	0	0	0	0
10-Nov	8	115	80	0	1	1 a	1 a	0	0	0	0	0	1	0	116	82	0	1	0	0
11-Nov	4	69	57	2	0	1	0	0	1	3	0	0	0	0	71	60	2	0	0	0
11-Nov	6	103	81	0	0	2	1	0	0	0	0	0	0	0	105	82	0	0	1	0
11-Nov	7	67	58	1	1	2 a	6 b	0	1	0	0	0	1	0	70	65	1	1	0	0
11-Nov	9	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
12-Nov	4	59	120	1	1	1	0	0	1	0	0	0	0	0	61	120	1	1	0	3
12-Nov	5	29	21	0	0	0	0	0	0	0	0	0	1	1	29	22	1	0	0	0
13-Nov	1	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
13-Nov	2	4	4	0	0	0	0	0	0	0	0	0	0	0	4	4	0	0	0	0
13-Nov	3	13	23	0	0	0	0	0	0	0	0	0	0	0	13	23	0	0	0	0
13-Nov	4	17	19	0	1	0	0	0	0	0	0	0	0	0	17	19	0	1	0	0
13-Nov	6	70	64	0	0	0	0	0	0	0	0	0	0	0	70	64	0	0	0	0
13-Nov	8	9	7	0	0	0	0	0	0	0	0	0	2	0	9	9	0	0	0	0
17-Nov	7	50	54	0	1	3	2	0	2	0	0	0	0	0	55	56	0	1	0	1
17-Nov	8	105	61	0	2	4	1 a	0	0	1	0	0	0	0	109	63	0	2	0	0
18-Nov	5	12	18	0	0	1 a	0	0	0	0	0	0	0	0	13	18	0	0	0	0
18-Nov	6	108	130	1	0	2	6	0	2	0	0	0	0	0	112	136	1	0	0	0
18-Nov	7	87	51	2	5	3	0	0	1	0	0	0	0	0	91	51	2	5	2	1

Appendix 3. Daily chinook salmon carcass recoveries, by reach, mark status and sex, in the Harrison River, 1997.

		Unmarked				Spagetti tag and secondary mark			Secondary mark only			Spagetti tag only			Total				Adipose fin absent	
Date	Reach	Male	Female	Unknown sex	Jack	Male	Female	Jack	Male	Female	Jack	Male	Female	Unknown sex	Male	Female	Unknown sex	Jack	Male	Female
19-Nov	4	55	49	1	1	1	0	0	0	0	0	0	0	0	56	49	1	1	1	1
19-Nov	5	5	12	0	0	0	0	0	0	0	0	0	0	0	5	12	0	0	0	0
19-Nov	6	104	98	4	1	0	4	0	1	0	0	1	0	0	106	102	4	1	1	0
20-Nov	3	4	10	0	0	0	0	0	0	0	0	0	0	0	4	10	0	0	0	1
20-Nov	4	102	150	6	2	2	1	0	0	0	0	0	0	0	104	151	6	2	0	2
20-Nov	5	11	19	0	0	0	0	0	0	0	0	0	0	0	11	19	0	0	0	0
21-Nov	7	53	25	0	1	0	1	0	0	0	0	0	0	0	53	26	0	1	1	0
21-Nov	8	115	57	1	7	4	3	0	0	0	0	0	1	0	119	61	1	7	1	0
24-Nov	3	4	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0
24-Nov	4	62	48	5	0	0	1	0	0	0	0	0	0	0	62	49	5	0	0	0
24-Nov	5	1	3	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0	0	0
24-Nov	6	51	32	10	2	0	0	1	0	0	0	0	0	0	51	32	10	3	0	2
24-Nov	7	40	27	8	2	0	1	0	1	0	0	0	0	0	41	28	8	2	0	0
25-Nov	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
25-Nov	2	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
25-Nov	3	14	24	0	0	0	0	0	0	0	0	0	0	0	14	24	0	0	0	0
25-Nov	4	74	111	11	2	3	3	1 a	0	0	0	0	0	0	77	114	11	3	0	1
26-Nov	3	0	3	1	0	0	0	0	0	0	0	0	0	0	0	3	1	0	0	0
26-Nov	4	27	39	1	0	0	0	0	0	0	0	0	0	0	27	39	1	0	0	0
26-Nov	5	52	49	6	1	1 a	0	0	0	0	0	0	1	0	53	50	6	1	0	1
26-Nov	7	17	12	0	0	0	0	0	0	0	0	0	0	0	17	12	0	0	0	0
26-Nov	8	49	29	0	3	1	1	0	0	0	0	0	0	0	50	30	0	3	0	0
27-Nov	3	6	6	0	0	0	0	0	0	0	0	0	0	0	6	6	0	0	0	2
27-Nov	4	28	42	1	0	0	0	0	0	0	0	0	0	0	28	42	1	0	0	0
27-Nov	6	33	54	5	1	0	2 a	0	1	0	0	0	0	0	34	56	5	1	0	1
27-Nov	7	26	29	5	4	0	0	0	0	0	0	0	0	0	26	29	5	4	0	1
27-Nov	8	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
01-Dec	6	2	0	1	1	0	0	0	0	0	0	0	0	0	2	0	1	1	0	0
01-Dec	7	12	7	1	0	1	0	0	0	0	0	0	0	0	13	7	1	0	0	0
01-Dec	8	59	23	5	0	0	1	0	1	0	0	0	0	0	60	24	5	0	0	0
02-Dec	4	13	19	5	1	0	0	0	0	0	0	0	0	0	13	19	5	1	0	1
02-Dec	5	5	7	0	0	0	0	0	0	0	0	0	0	0	5	7	0	0	0	0
03-Dec	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
03-Dec	5	8	8	0	0	0	0	0	0	0	0	0	0	0	8	8	0	0	0	0
03-Dec	8	9	13	0	0	0	0	0	0	0	0	0	0	0	9	13	0	0	0	0
03-Dec	9	1	3	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0	0	0

Appendix 3. Daily chinook salmon carcass recoveries, by reach, mark status and sex, in the Harrison River, 1997.

		Unmarked				Spagetti tag and secondary mark			Secondary mark only			Spagetti tag only			Total				Adipose fin absent	
Date	Reach	Male	Female	Unknown sex	Jack	Male	Female	Jack	Male	Female	Jack	Male	Female	Unknown sex	Male	Female	Unknown sex	Jack	Male	Female
Total	1	7	15	0	0	0	1	0	0	0	0	0	0	0	7	16	0	0	0	0
	2	11	11	0	0	0	0	0	0	0	0	0	0	0	11	11	0	0	1	0
	3	43	76	1	0	0	0	0	0	0	0	0	0	0	43	76	1	0	0	4
	4	599	770	35	11	8	7	1	3	3	1	0	0	0	610	780	35	13	1	8
	5	153	172	6	1	2	0	0	0	0	0	0	2	1	155	174	7	1	0	1
	6	573	528	21	6	5	15	1	4	0	0	1	0	0	583	543	21	7	2	3
	7	483	346	18	19	14	11	0	5	0	0	0	2	0	502	359	18	19	5	5
	8	472	279	6	13	11	7	0	1	1	0	0	4	0	484	291	6	13	1	0
	Unknown	1	5	0	0	0	0	0	0	0	0	0	0	0	1	5	0	0	0	0
	Total	2,342	2,202	87	50	40	41	2	13	4	1	1	8	1	2,396	2,255	88	53	10	21

a. Includes 1 which was recaptured and released during tag application.

b. Includes 2 which were recaptured and released during tag application.

Appendix 4. Percentage at age and mean length at age, by AFC status and sex, of chinook carcasses recovered on the Harrison River spawning grounds, 1996.

		Female			Male			Jack		
Adipose fin status	Age [a]	Sample size	Percent	Mean POH length (cm)	Sample size	Percent	Mean POH length (cm)	Sample size	Percent	Mean POH length (cm)
Unmarked	5/1	20	6.4%	77.5	9	3.4%	81.2	0	0.0%	0.0
	4/1	168	53.5%	72.2	66	24.9%	74.5	1	2.2%	41.0
	3/1	126	40.1%	65.5	190	71.7%	64.5	33	71.7%	48.7
	2/1	0	0.0%	0.0	0	0.0%	0.0	12	26.1%	40.6
	Sub-1	314	100.0%	69.9	265	100.0%	67.6	46	100.0%	46.4
	Sub-2	0	0.0%	-	0	0.0%	-	0	0.0%	-
	Total	330	50.2%	70.0	276	42.0%	67.5	51	7.8%	46.3
	Flesh colour									
	Red	0	0.0%	0.0	0	0.0%	0.0	0	0.0%	0.0
	White	329	100.0%	70.0	276	100.0%	67.5	51	100.0%	46.3
Adipose fin clip	5/1	0	0.0%	0.0	0	0.0%	0.0	0	-	0.0
	4/1	13	61.9%	72.7	4	44.4%	75.1	0	-	0.0
	3/1	8	38.1%	66.3	5	55.6%	63.6	0	-	0.0
	2/1	0	0.0%	0.0	0	0.0%	0.0	0	-	0.0
	Sub-1	21	100.0%	70.3	9	100.0%	68.7	0	-	0.0
	Sub-2	0	0.0%	-	0	0.0%	-	0	-	-
	Total	21	67.7%	70.3	10	32.3%	68.1	0	0.0%	0.0
	Flesh colour									
	Red	0	0.0%	-	0	0.0%	-	0	-	-
	White	21	100.0%	70.3	10	100.0%	68.1	0	-	0.0
Total	5/1	20	6.0%	77.5	9	3.3%	81.2	0	0.0%	0.0
	4/1	181	54.0%	72.3	70	25.5%	74.5	1	2.2%	41.0
	3/1	134	40.0%	65.5	195	71.2%	64.5	33	71.7%	48.7
	2/1	0	0.0%	0.0	0	0.0%	0.0	12	26.1%	40.6
	Sub-1	335	100.0%	69.9	274	100.0%	67.6	46	100.0%	46.4
	Sub-2	0	0.0%	-	0	0.0%	-	0	0.0%	-
	Total	351	51.0%	70.0	286	41.6%	67.5	51	7.4%	46.3
	Flesh colour									
	Red	0	0.0%	0.0	0	0.0%	0.0	0	0.0%	0.0
	White	350	100.0%	70.0	286	100.0%	67.5	51	100.0%	46.3

a. Totals include unageable samples and samples of unknown adipose status or flesh colour but exclude carcasses with no POH length record.

Appendix 5. AFC and CWT sampling of chinook salmon recovered on the Harrison River spawning grounds, 1997.

			Male	Female	Unknown sex	Jack	Total
Sample size			289	353	1	52	695
Number with AFCs			10	21	0	0	31
Questionable or Partial AFCs			1	2	0	0	3
AFC carcass without a head			0	2	0	0	2
CWT lost during processing			0	0	0	0	0
AFC carcass without a CWT			2	3	0	0	5
AFC carcass with questionable or partial clip and without a CWT			1	1	0	0	2
CWTs recovered:							
Code	Brood	Release site					
18-12-31	1993	Chehalis Hatchery	1	4	0	0	5
18-12-32	1993	Chehalis Hatchery	2	1	0	0	3
18-12-33	1993	Chehalis Hatchery	0	5	0	0	5
18-19-45	1994	Chehalis Hatchery	2	2	0	0	4
18-19-46	1994	Chehalis Hatchery	3	1	0	0	4
18-02-13	1994	Stave River	0	3	0	0	3
Total			8	16	0	0	24
AFC incidence (%) a			3.1%	5.4%	0.0%	0.0%	4.3%
CWT loss (%) a			11.1%	11.1%	-	-	11.1%
Spatial pattern in AFC incidence: a							
Upper Section (reaches 1,2)			5.6%	0.0%	-	-	2.2%
Middle Section (reaches 3,4,5)			0.2%	1.3%	0.0%	0.0%	0.8%
Lower Section (reaches 6,7,8)			0.4%	0.5%	0.0%	0.0%	0.4%
Temporal pattern in AFC incidence: a							
Early Period (18-Oct to 08-Nov)			0.6%	0.6%	0.0%	0.0%	0.6%
Middle Period (9-Nov to 22 Nov)			0.5%	0.6%	0.0%	0.0%	0.5%
Late Period (23-Nov to 06-Dec)			0.0%	1.5%	0.0%	0.0%	0.7%

a. Excludes carcasses with questionable or partail AFCs (Appendix 6).

Appendix 6. Incidence of CWT loss, by carcass condition, eye status, and AFC condition, in AFC chinook salmon carcasses recovered on the Harrison River spawning grounds, 1997.

Observation	Condition	Number a	CWT absent	CWT loss (%)
Carcass condtion	Fresh	12	1	8.3%
	Moderately fresh	11	2	18.2%
	Moderately rotten	6	2	33.3%
	Rotten	0	0	-
Eyes present	None	6	2	33.3%
	One	8	0	0.0%
	Two	15	3	20.0%
Adipose fin clip b	Complete	25	2	8.0%
	Partial	1	1	100.0%
	Questionable	1	1	100.0%

a. Excludes 2 heads lost during processing.

b. Excludes 2 AFC carcasses with clip condition not reported.

Appendix 7. Spawning success, by mark status, in female chinook carcassess recovered on the Harrison River spawning grounds, 1997.

Mark status		Percent spawned 0%	50%	100	Weighted mean
Spaghetti tag or secondary mark	Number	2	0	44	
	Percent	4.3%	0.0%	95.7%	95.7%
Unmarked	Number	2	12	274	
	Percent	0.7%	4.2%	95.1%	97.2%
Total	Number	4	12	318	
	Percent	1.2%	3.6%	95.2%	97.0%